AMAZON ORIGINAL

# THE AERONAUTS

## 5E Instructional Planning Model

## DENSITY LESSON 2: DENSITY—FLOAT OR SINK?

**OVERVIEW:** Determine the relationship between density and buoyancy.

## LEARNING TARGETS:

Students can:

- Use a digital simulation to collect science data.
- Use displacement to determine the volume of an object.
- Calculate density.
- Draw molecule diagrams to model the density of solids and liquids.
- Predict if a material will float or sink given the density of the material and the density of the fluid.
- Compare the density of the gas inside the balloon used in the movie *The Aeronauts* with the density of the gas in our atmosphere.

## NEXT GENERATION SCIENCE STANDARDS

| High School Forces and Interactions | | |
|---|---|---|
| **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Cross Cutting Concepts** |
| **Developing and Using Models**<br>♦ Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-8)<br><br>**Planning and Carrying Out Investigations**<br>♦ Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence; and in the design, decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time) and refine the design accordingly. (HS-PS1-3) | **PS1.A: Structure and Properties of Matter**<br>♦ Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)<br>♦ The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1) | **Structure and Function**<br>♦ Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2- 6) |

| | | |
|---|---|---|
| **Obtaining, Evaluating and Communicating Information**<br>♦ Communicate scientific and technical information (e.g., about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually and mathematically). (HS-PS2-6) | | |

## ENGAGEMENT: *THE AERONAUTS* MOVIE TRAILER AND REAL-WORLD CONNECTIONS

| Materials | Procedures | Sample Questions / Teacher Hints |
|---|---|---|
| ♦ Computer<br>♦ Projector<br>♦ Density—Float or Sink? PowerPoint Presentation (Slides 1-11)<br>♦ Density—Float or Sink? PowerPoint Guide (provides teaching information and talking points for each slide, almost like a script) | **_The Aeronauts_ Movie Trailer** | |
| | Show trailer for *The Aeronauts* movie.<br>https://youtu.be/fgyTRhDZNbk?t=21<br><br>♦ (See PowerPoint Slide 2) | See PowerPoint guide for Slide 2. |
| | Introduce learning targets and lesson agenda.<br>(See PowerPoint Slides 3-4.) | See PowerPoint guide for Slides 3-4. |
| | **Real-World Connections and Career Connections** | |
| | (See PowerPoint Slides 6-11.) | See PowerPoint guide for Slides 6-11.<br><br>Teacher Hint: If you and your students did Density Lesson 1, use these slides for a quick review of real-world and career connections. |

## EXPLORATION: DENSITY LAB SIMULATION

| Materials | Procedures | Sample Questions / Teacher Hints |
|---|---|---|
| ♦ Computer<br>♦ Projector<br>♦ Density—Float or Sink? PowerPoint Presentation Slides 12-22)<br>♦ Density—Float or Sink? PowerPoint Guide (provides teaching information and talking points for each slide, almost like a script)<br>♦ Student Data Recording Worksheet: Density—Float or Sink?<br>♦ Key—Student Data Recording Worksheet: Density—Float or Sink?<br>♦ Sim Bucket Density Lab Simulation—https://pbslm-contrib.s3.amazonaws.com/WGBH/arct15/SimBucket/Simulations/densitylab/content/index.html | **States of Matter and Density Discussion** | |
| | (See PowerPoint Slides 12-13.)<br>♦ Teachers use molecular model pictures of a solid, liquid and gas to remind students of the molecular structure of solids, liquids and gases, and to explain why liquids and gases are considered fluids. | (See PowerPoint guide for Slides 12-13.)<br>♦ Teacher Hint 1: If you and your students did Density Lesson 1, where the focus was on solids, now focus the discussion on the difference between solids and liquids.<br>♦ Teacher Hint 2: To be able to transfer what students are learning in the simulation to aeronautics, students need to understand that air (and any gas) is classified as a fluid. Use the term "fluid" instead of "liquid" throughout the activity. |
| | **Interact with Digital Simulation** | |
| | (See PowerPoint Slides 14-21.)<br><br>Students will use the digital simulation to gather volume and mass data of various materials. Students will record simulation data on the student data recording worksheet. The steps for this part of the lesson are:<br>♦ Students interact with the simulation to learn how it works. (Slides 14-15)<br>♦ Students are introduced to the purpose for doing the lab (Slide 16)<br>♦ Experimental procedure overview (Slide 17)<br>♦ Identification of variables (Slide 18)<br>♦ Students collect data from the simulation, completing data table, calculating the density of the materials as they go. (Slide 19)<br>♦ Students graph simulation data. (Slide 20)<br>♦ Students make a claim based on the evidence gathered from the simulation (Slides 21-22) | (See PowerPoint guide for Slides 14-21.)<br>♦ The slides that show students how to complete the data table and graph the data are animated.<br>♦ Teacher Hint 1: If you and your students did Density Lesson 1, skip the simulation exploration (Slides 14-15).<br>♦ Teacher Hint 2: The simulation does not tell students the volume of the objects. The students will use displacement of fluid to determine the volume of the objects. Slide 18 shows students how to do this.<br>♦ Teacher Hint 3: Sometimes there will be a glitch in the simulation. If this happens, the materials that they are testing disappear, so you will need to refresh the simulation. |

## EXPLANATION: MOLECULAR MODELS

| Materials | Procedures | Sample Questions / Teacher Hints |
|---|---|---|
| ♦ Computer<br>♦ Projector<br>♦ Density—Float or Sink? PowerPoint Presentation (slides 23-34)<br>♦ Density—Float or Sink? PowerPoint Guide (provides teaching information and talking points for each slide, almost like a script)<br>♦ Student Data Recording Worksheet: Density—Float or Sink?<br>♦ Key—Student Data Recording Worksheet: Density—Float or Sink?<br>♦ Pencil | **Models** | |
| | ♦ (See PowerPoint Slide 23.)<br>♦ Discuss what models are and how models can be used in science to communicate ideas to others.<br>♦ Students set up molecule diagrams for a solid that has a density higher than water, a solid that has a density lower than water, and water. | (See PowerPoint guide for Slide 22.)<br>♦ PowerPoint slide includes step-by-step animations. |
| | **Atomic Structure and Density** | |
| | (See PowerPoint Slides 24-31.)<br><br>Teacher-led discussion to help students discover the relationship between the atomic mass and density.<br><br>The steps for this part of the lesson are:<br>♦ Refresher on atomic structure (Slide 24)<br>♦ Look at the atomic structure of nickel, as an example of a solid with a density higher than the density of water. (Slides 25-26)<br>♦ Look at the molecular structure of Styrofoam. Styrofoam is a solid with a density lower than the density of water. (Slides 27-29)<br>♦ Update molecular modes to communicate differences between Nickel and Styrofoam. (Slide 30)<br>♦ Update molecular models to include water, with an emphasis on the difference between solids and liquids and the factors that affect the density of materials (atomic mass of molecules and the amount of atoms/molecules). (Slide 31) | (See PowerPoint guide for Slides 23-31.)<br><br>PowerPoint slides include animations.<br>♦ Teacher Hint 1: If you and your students did Density Lesson 1, the students are familiar with the molecular structure of a metal and Styrofoam. Use Slides 24-30 as a review.<br>♦ Teacher Hint 2: Students did not necessarily use a fluid that has the same density of water (1g/mL) in their simulation investigation. Water is used as the model for liquid to ensure the models of the solids (nickel and Styrofoam) have densities that are less than and greater than the model for liquid (water).<br>♦ Teacher Hint 3: Students are going to use color to represent various molecules with darker shades representing high-mass molecules and light shades representing low-mass molecules. This can be done with a pencil by varying the pressure or intensity of the shading, or colored pencils/markers if there are various colors of the same shade.<br>♦ Teacher Hint 4: This discussion is highly teacher-led. Depending on teacher familiarity/comfort with this content, use these slides to guide a class discussion, rather than a lecture. |

## EXPLANATION: MOLECULAR MODELS CONT'D

### Diagram 2: Buoyancy

| | |
|---|---|
| (See PowerPoint Slides 32-33.)<br><br>Students create a diagram to compare the density of liquid they used in their simulation investigation with the density of a solid that floats and the density of a solid that is sunken. | (See PowerPoint guide for Slides 32-33.) |

### Post-Lab Discussion

| | |
|---|---|
| (See PowerPoint Slide 34.)<br><br>Students reflect on the lab using post-lab discussion question. Discussion points include:<br>♦ Summary of procedure;<br>♦ Reason bar graph was the appropriate choice for this data;<br>♦ Reason objects float and sink, as discovered in this simulation investigation;<br>♦ How both the graph and data table help us compare the density of materials;<br>♦ Strengths and weaknesses of the models used in this investigation (simulation and molecular models); and<br>♦ Other research questions that can be answered by the simulation. | (See PowerPoint guide for Slide 34.)<br>♦ Teacher Hint: Have students prepare for the discussion by talking through the questions with an elbow partner. Then use the fishbowl strategy to have whole class discussions around these questions. https://www.facinghistory.org/resource-library/teaching-strategies/fishbowl |

## ENRICH: LOOK AT DENSITY/BUOYANCY IN *THE AERONAUTS*

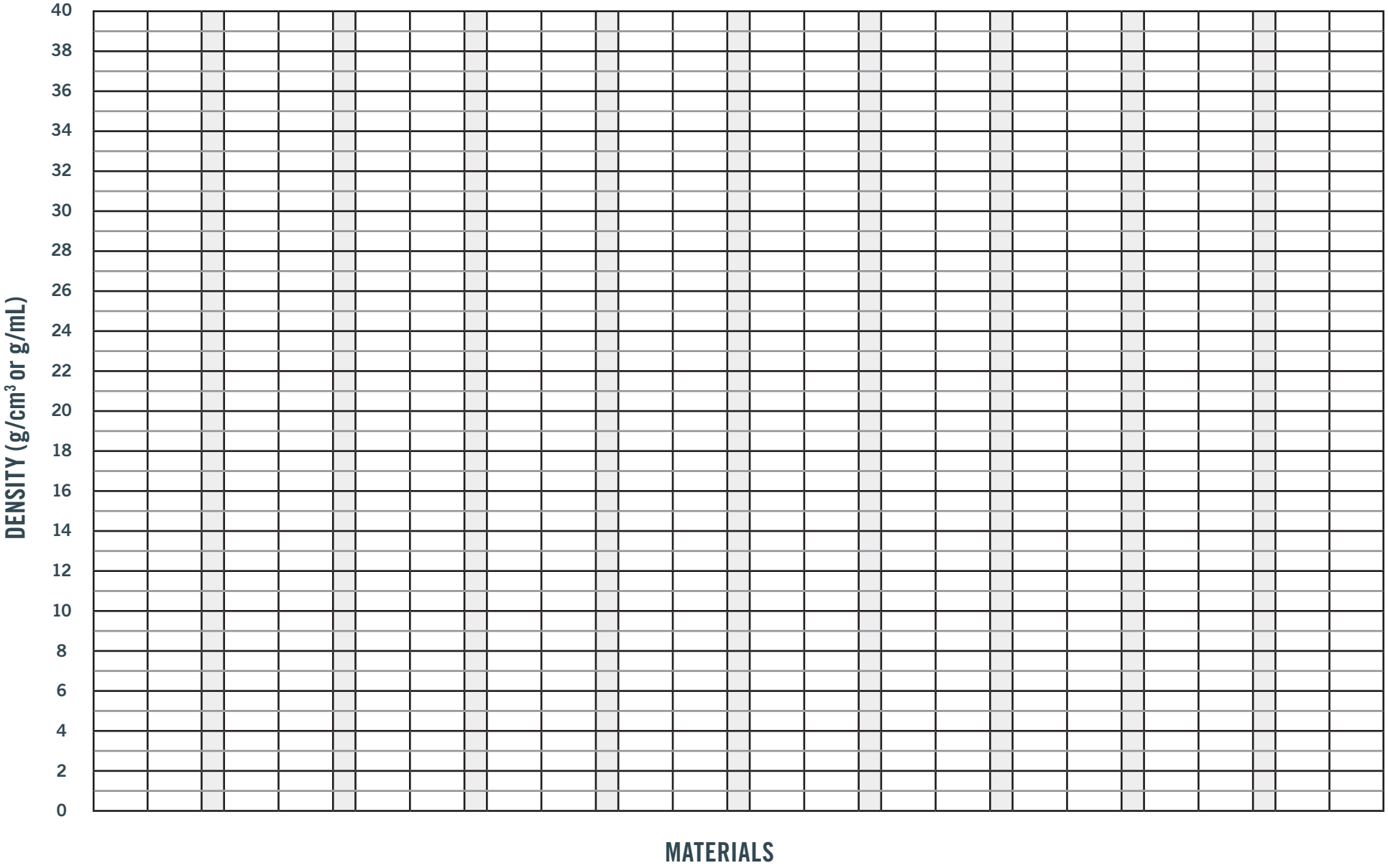
| Materials | Procedures | Sample Questions / Teacher Hints |
|---|---|---|
| ♦ Computer<br>♦ Projector<br>♦ Density—Float or Sink? PowerPoint Presentation (Slides 35-36)<br>♦ Density—Float or Sink? PowerPoint Guide (provides teaching information and talking points for each slide, almost like a script) | **Density / Buoyancy in *The Aeronauts* Movie** | |
| | (See PowerPoint Slides 35-36.)<br>♦ Students will do research to learn about the density of our atmosphere at STP (standard temperature/pressure) and compare the density of our atmosphere with the density of helium, the gas inside a helium balloon, at STP.<br>♦ Using what they learned about buoyancy, students will explain why a helium balloon ascends in our atmosphere.<br>♦ Students will also research how aeronauts make their balloons descend. | (See PowerPoint guide for Slides 35-36.) |

## EVALUATION

- The grading guide provides suggested point values and grading criteria for the various components of the student data recording worksheet.
- Use the "Float or Sink? Balloon/atmosphere density paragraph rubric" to grade student paragraphs.

# DENSITY: FLOAT OR SINK?

**GRAPH PAPER**



NAME: _____

WORKSHEET

# DENSITY—FLOAT OR SINK?

## PURPOSE / VARIABLES

Purpose: _____

Independent: _____ Dependent: _____ Constant: _____

## DATA TABLE

| Solid material | Mass of the solid material | Fluid volume | | | Volume of the solid material | Density of the solid material $\rho = m/v$ | Fluid density | Buoyancy float or sink |
|---|---|---|---|---|---|---|---|---|
| | | Final volume ($v_f$) | Initial volume ($v_i$) | Volume of displaced fluid $v_f - v_i$ | | | | |
| | | | | | | | | |
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| | | | | | | | | |

NAME: _____

WORKSHEET

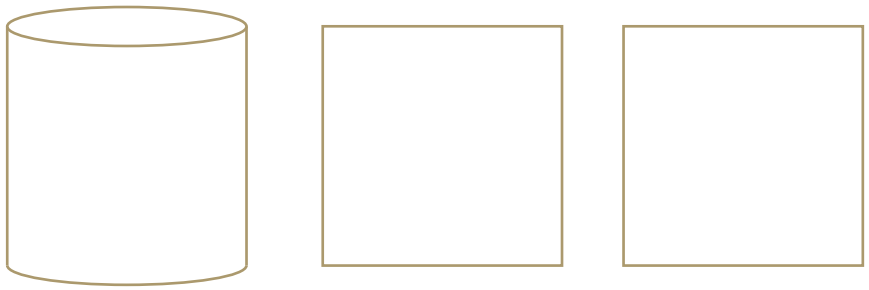
## CLAIM

_____

_____

## DIAGRAM 1

Diagram Key

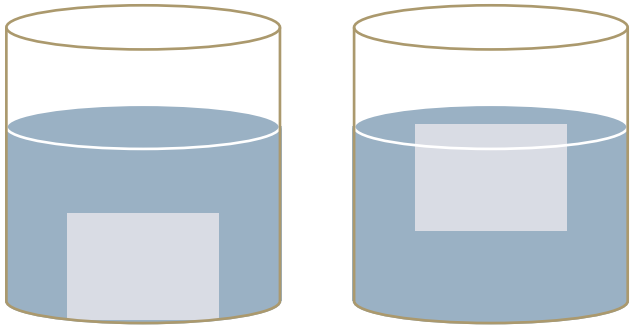


Water ($H_2O$)

Density
less than water

Density
greater than water

## DIAGRAM 2



NAME: _____

GRADING GUIDE

# DENSITY—FLOAT OR SINK?

## PURPOSE / VARIABLES (4 points)

Purpose: To determine the relationship between density and buoyancy 1 point

Independent: density of the solid (g/mL) 1 point Dependent: buoyancy (floating or sinking) 1 point Constant: fluid density 1 point

## DATA TABLE (15 points - see next page)

| Solid material | Mass of the solid material | Fluid volume | | | Volume of the solid material | Density of the solid material $\rho = m/v$ | Fluid density | Buoyancy float or sink |
|---|---|---|---|---|---|---|---|---|
| | | Final volume ($v_f$) | Initial volume ($v_i$) | Volume of displaced fluid $v_f - v_i$ | | | | |
| example | 5.65 | 36.4 mL | 25.5 mL | 10.9 mL | 10.9 cm3 | 0.29 g/cm3 | 2.5 g/mL | float |
| material A | 10.2 g | 27.5 mL | 25.5 mL | 2 mL | 2 cm3 | 5.1 g/cm3 | 2.5 g/mL | sink |
| material B | 14.85 g | 39.5 mL | 25.5 mL | 14 mL | 14 cm3 | 1.1 g/cm3 | 2.5 g/mL | float |
| material C | 18.25 g | 38.4 mL | 25.5 mL | 12.9 mL | 12.9 cm3 | 1.4 g/cm3 | 2.5 g/mL | float |
| material D | 11.15 g | 25.9 mL | 25.5 mL | 0.4 mL | 0.4 cm3 | 27.9 g/cm3 | 2.5 g/mL | sink |
| material E | 3.4 g | 26.2 mL | 25.5 mL | 0.7 mL | 0.7 cm3 | 4.9 g/cm3 | 2.5 g/mL | sink |
| material F | 7.25 g | 27 mL | 25.5 mL | 1.5 mL | 1.5 cm3 | 4.8 g/cm3 | 2.5 g/mL | sink |
| material G | 3.6 g | 27.4 mL | 25.5 mL | 1.9 mL | 1.9 cm3 | 1.9 g/cm3 | 2.5 g/mL | float |
| material H | 15.7 g | 26.8 mL | 25.5 mL | 1.3 mL | 1.3 cm3 | 12.1 g/cm3 | 2.5 g/mL | sink |
| material I | 11.15 g | 26.8 mL | 25.5 mL | 1.3 mL | 1.3 cm3 | 8.6 g/cm3 | 2.5 g/mL | sink |
| material J | 0.9 g | 26.4 mL | 25.5 mL | 0.9 mL | 0.9 cm3 | 1.0 g/cm3 | 2.5 g/mL | float |

## DATA TABLE (15 points)

All data points include units (mL, g, $cm^3$, $g/cm^3$)—5 points
Accurate calculation of displaced fluid—5 points (subtract ½ point for each error)
Accurate calculation of density—5 points (subtract ½ point for each error)
All data recorded—subtract 1 point for each missing row.

## GRAPH separate page (15 points)

All bars labeled (material A, material B, etc.)—3 points
All bars drawn to the correct height—10 points
(subtract ½ point for each bar not drawn to the correct height)
Key included—2 points
All objects graphed—subtract 1 point for each missing object

NAME: _____

GRADING GUIDE

## CLAIM (3 points)

When the density of a solid is less than the density of the fluid, the object will float.

When the density of a solid is greater than the density of the fluid, the object will sink.

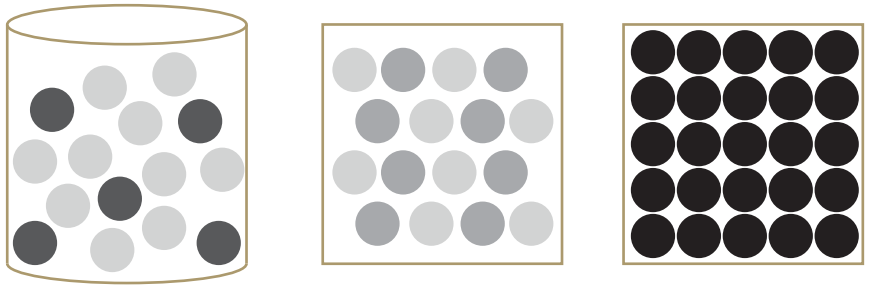
Both claims are written in sentence form—1 point
Both claims are accurate—2 points

## DIAGRAM 1 (10 points)

Students labeled each diagram with the materials and material density—1 point
Students used a different color for each element, and darkness of the shade correlates to the mass of the atoms—3 points

Diagram Key

- Nickel (58.69 AMU)
- Oxygen (15.99 AMU)
- Carbon (12.01 AMU)
- Hydrogen (1.01 AMU)



Water ($H_2O$)

Density less than water

material: Styrofoam / Styrene ($C_8H_8$)
density: 0.05 g/cm$^3$

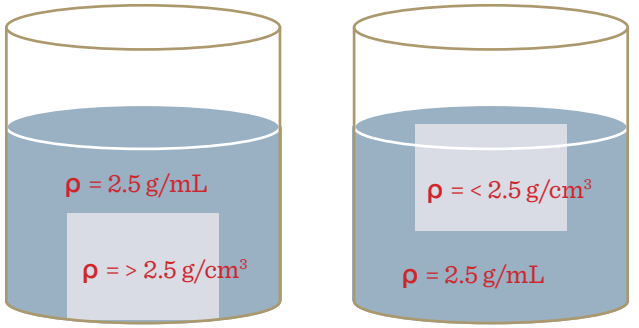
Density greater than water

material: Nickel (Au)
density: 8.9 g/cm$^3$

For solids, atoms drawn in a regular pattern—2 points
For water, atoms drawn in a random pattern—1 point
Nickel has more atoms tightly packed; foam diagram shows there are fewer atoms that are not as tightly packed—1 point
Key is completed to communicate the atom each color represents, and atomic mass—2 points

## DIAGRAM 2 (2 to 3 points)

Density of fluid labeled in both beakers—1 point
Density of floating object is labeled as being less than the density of the fluid—1 point
Density of sunken object is labeled as being greater than the density of the fluid—1 point



# RUBRIC: BALLOON / ATMOSPHERE DENSITY PARAGRAPH
## FLOAT OR SINK?

**NAME:** _____

| | 4 points | 3 points | 2 points | 1 point |
|---|---|---|---|---|
| **Gas in the balloon** | | | | Student correctly identified the gas inside the balloon as helium. |
| **STP** | | | | Student accurately described STP (standard temperature and pressure). |
| **Identification of density** | | | Student correctly identified the density of helium and air at STP<br>**AND**<br>Density values reported in comparable units like g/L. | Student did not correctly identify the density of one of the gases at STP<br>**OR**<br>Student did not report density values in comparable units. |
| **Explanation of floating or sinking** | Student clearly communicated that the density of gas inside balloon would be less than density of air outside the balloon.<br>**AND**<br>Student **accurately explained** that the balloon would ascend because the density of the balloon is less than the density of the air. | Student clearly communicated that the density of gas inside balloon would be less than density of air outside the balloon.<br>**AND**<br>Student **implied** that the balloon would ascend because the density of the balloon is less than the density of the air. | Student did communicate that the density of gas inside the balloon would be less than the density of air outside the balloon.<br>**AND**<br>Student did not demonstrate an understanding of the relationship between density and buoyancy. | Student did **not** communicate that the density of gas inside the balloon would be less than the density of air outside the balloon.<br>**AND**<br>Student demonstrated **no** understanding of the relationship between density and buoyancy. |
| **Balloon descent** | | | | Student correctly explained what a gas balloon pilot would do to cause the balloon to descend. |

## RUBRIC: BALLOON / ATMOSPHERE DENSITY PARAGRAPH (FLOAT OR SINK?)

| | | | | |
|---|---|---|---|---|
| **Mechanics**<br>♦ Capitalization<br>♦ Punctuation<br>♦ Spelling | | No errors or only one error | Two to four errors | Five or more errors |
| **Sources Cited** | | | All sources cited. | Some sources cited. |
| **Academic Integrity** | Plagiarism will result in a zero. | | | |